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ESTIMATION OF THE PERSONAL DISCOUNT RATE

I. INTRODUCTION

This paper presents some estimates of the personal discount rate of Navy enlisted personnel. Many of these individuals can receive a bonus payment of up to $20,000 if they choose to reenlist after completing their initial term of service. Prior to April 1979, the reenlistment bonus was paid in annual installments at the beginning of each year of reenlistment. In fiscal year 1979 (FY79), the Department of Defense requested sufficient funds to begin making lump sum payments and, starting on 1 April 1979, the entire bonus has been paid as a lump-sum at the date of reenlistment. The rationale for this change is a familiar one. Because individuals discount deferred payments, lump-sum bonuses should induce more reenlistment than installment bonuses. By comparing the effects of bonuses before and after the policy change, we were able to estimate the differential impact of lump-sum and installment bonuses. We then use these estimates to compute the implied discount rate.

We find that Navy enlisted personnel have a real discount rate of about 17 percent. This estimate may seem high, but it is comparable to Heckman's (1976) estimates of 18 to 20 percent and Landsberger's (1971) estimates of 9 to 27 percent, and lower than Friedman's (1957) estimate of 30 percent.

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There would seem to be a clear policy implication of our findings. As long as the real discount rate relevant to the Government is less than 17 percent, the payment of lump-sum bonuses would appear to be more efficient than the payment of installment bonuses. There is another factor which must be considered, however. Although payment of lump-sum bonuses increases the incentive to reenlist it also decreases the incentive to complete the reenlistment contract, thus leading to higher costs of contract enforcement and collection of unfulfilled obligations.

Recognizing the difficulties in recoupment of lump-sum bonuses, Congress decided to partially return to the payment of bonuses in installments.[1] In Fiscal year 1982, 50% of the reenlistment bonus will be paid as a lump-sum while the remainder will be paid in annual installments over the reenlistment period. The economic efficiency of such a policy depends upon the net effects of the two offsetting costs -- the increased costs to the government of paying deferred bonuses versus the decreased costs of contract enforcement under the installment policy. Using our discount rate estimates we are able to compute the implicit tradeoffs made by Congress and the values assigned to these respective costs.

[1] Another Congressional rationale for returning to installment payments is referred to as the "what have you done for me lately" syndrome -- a result of individuals serving extended obligations long after receiving their bonus payments. Although somewhat misstated, the economic implication is also one of difficulty in encouraging and enforcing contract completion.

II. EFFECTS OF BONUSES ON REENLISTMENT RATES

Individuals enlisting in the military services sign an employment or enlistment contract with an initial commitment to serve between three and six years. The duration of the contract depends upon the skill or military occupation they enter and the initial training they receive. After completing their initial contract, these individuals may choose to reenlist for another period again ranging between three and six years.

Since military pay and allowances are based only on rank and experience and not on occupational skill, the services have experienced shortages in certain skills with high private sector demand (such as nuclear power plant operators and data system technicians) or in skills with extremely arduous working conditions (such as boiler technicians). In order to offer more competitive wages in these skills, the military services have been authorized to pay bonuses to enlistees or reenlistees at various points in their careers.

Prior to April 1979, reenlistment bonuses were paid in annual installments. At the beginning of each year of the reenlistment period, the individual received a bonus payment equal to the product of:

(1) monthly basic pay at the date of reenlistment, and

(2) a "bonus multiple" ranging between 0 and 6.

In the Navy, for example, approximately 100 skills are assigned a bonus multiple at the beginning of each fiscal year. These bonus multiples are determined on the basis of the manning shortage or surplus anticipated in each skill.

Starting on April 1, 1979, the entire bonus has been paid as a lump-sum at the date of reenlistment. Hence, the bonus payment is equal to the product of:

(1) monthly basic pay at the date of reenlistment

(2) the bonus multiple

(3) length of reenlistment measured in years.

The undiscounted sum of the reenlistment bonus remains the same for the two methods of payment, only the timing of payments differs.

The reenlistment rate is defined as the fraction of individuals who choose to reenlist (remain in the service) among those whose initial enlistments expire within a given fiscal year. To estimate the effect of bonuses on the reenlistment rate, we pooled annual data over three fiscal years (FY78-FY80) for the 87 Navy skills having complete data. Since the fiscal year begins on 1 October, the policy change on 1 April 1979 occurred exactly half-way into FY79. Hence our data set contains one year under the old policy, one transition year, and one year under the new policy.

We expressed the reenlistment rate as a logistic function of the bonus multiple and other variables; i.e.,

$$(1) \qquad \log [R/(1-R)] = \mathbf{X}\mathbf{b} + \mathbf{u}$$

where **R** is a vector of reenlistment rates for each skill and **b** is the vector of coefficients of the independent variables. Because the disturbances in equation (1), u, are heteroskedastic, we estimated equation (1) using weighted least squares.[1]

We used two specifications for equation (1). Under the first specification, we introduced a set of dummy variables for the FY79 and FY80 observations. These dummy variables were intended to capture the effects of time-dependent variables other than bonus multiple which influenced reenlistment decisions in our sample period. Under the second specification, we replaced the dummy variables by the unemployment rate among males aged 25-34. It should be noted that this variable only took on three distinct values in our data set, one for each fiscal year. Hence the two specifications are quite similar, except that the second constrains the time-dependence to occur through the unemployment rate.[2]

Under both specifications, we included interaction variables between the bonus multiple and fiscal year dummy variables. These interaction variables enable us to estimate the effects of bonuses on reenlistment rates

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[1]Our observations are not on individuals, but rather are cell averages within each skill. Hence R is the sample proportion who reenlist within a skill. Cox (pp. 104-107) demonstrates that

$$Var(u_i) = [N_i R_i (1-R_i)]^{-1}$$

where N_i is the cell size. Thus the weighted least squares procedure places more weight on the skills having greater numbers N_i or having R_i closer to 0.5.

[2]It would be impossible to include both the fiscal year dummy variables and the unemployment rate into the regression, since they would be perfectly collinear.

separately under the two policy periods and the transition period. Hence we may test the hypothesis that the policy change in FY79 led to an increase in the effect of bonuses.

Our regression results are reported in Table 1. The two specifications yield almost identical estimates of the effects of bonuses. The interaction coefficients are both positive, and the FY80 interaction coefficient is larger than the FY79 interaction coefficient.

	Specification 1	Specification 2
Intercept	-.7941	-.8569
	(5.98)	(3.23)
Bonus	.1840	.1914
	(3.98)	(5.96)
FY79	-.0410	--
	(0.25)	--
FY80	-.0166	--
	(0.11)	--
Unemployment	--	.0081
	--	(0.16)
Bonus x FY79	.0427	.0329
	(0.69)	(0.76)
Bonus x FY80	.0747	.0664
	(1.23)	(1.38)
R^2	.343	.342
N	261	261

(t-ratios in parentheses)

Table 1 - Regression estimates of equation (1).

Table 2 reports the partial derivatives of the reenlistment rate with respect to the bonus multiple for each of the three fiscal years.[1] Again, the two

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[1] Differentiating equation (1), we find that the partial derivative of R with respect to the FY78 bonus multiple equals the bonus coefficient times the factor R(1-R). We evaluated R at its sample mean of .40 in computing this factor. For FY79 and FY80 the result is similar, except that the sum of the bonus coefficient and the appropriate interaction coefficient must be multiplied by R(1-R).

specifications are nearly identical. We find that the installment bonuses paid in FY78 were only 71.0 percent as

	Specification 1	Specification 2
FY78	.044	.046
FY79	.054	.054
FY80	.062	.062

Table 2 - Partial derivatives of R (dR/dB).

effective as the lump-sum bonuses paid in FY80 under the first specification, and 74.2 percent as effective under the second specification. Since the first specification provided a slightly better fit to the data, we will employ 71.0 percent as the relative effectiveness of installment bonuses.

III. ESTIMATION OF THE IMPLIED DISCOUNT RATE

In comparing the effects of bonuses on the reenlistment rate in FY78 and FY80, we have found that the installment bonuses paid in FY78 were only 71.0 percent as effective as the lump-sum bonuses paid in FY80. In this section we compute the discount rate of the "marginal" reenlistee implied by this comparison. We assume that the nominal discount rate is equal to the real discount rate plus the expected rate of price inflation. We will first solve for the nominal discount rate and then compute the real discount rate by subtracting the observed rate of inflation, thus using the observed inflation rate as our estimate of the expected rate.

Consider an installment bonus of \$1 per year. Assuming a four-year length of reenlistment (the majority of reenlistments are for four year terms)[1], the discounted present value of the installment bonus at a nominal discount rate of r is equal to:

$$(2) \qquad \sum_{i=1}^{4} \frac{1}{(1+r)^{i-1}} = \frac{1+r}{r}\left(1-\frac{1}{(1+r)^4}\right)$$

By contrast, the discounted present value of a \$4 lump-sum bonus is simply \$4. Hence at a nominal discount rate of r, the effectiveness of an installment bonus relative to a lump-sum bonus is equal to the ratio of the discounted present values:

$$(3) \qquad 0.25\, \frac{1+r}{r}\left(1-\frac{1}{(1+r)^4}\right)$$

To estimate the nominal discount rate, we set equation (3) equal to .710 (the measured ratio of relative bonus effectiveness) and solve for r.[2] We find that, on the margin, Navy enlisted personnel have a nominal discount rate of 29.1 percent[3]. Since the Consumer Price Index grew at an

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[1]The length of reenlistment is chosen by the reenlistee and will not be independent of the method of bonus payment. A paper is available from the authors discussing this issue.

[2]This is a third-degree polynomial equation in r. However, applying Descartes' rule of signs, the solution is unique since the installment payments are all positive.

[3]It is only a coincidence that the estimated nominal discount rate is approximately equal to (1-.71).

average annual rate of 10.6 percent over our sample period, this implies a real marginal discount rate of 18.5 percent.[1]

IV. THE EFFECTS OF PROGRESSIVE INCOME TAXATION

Our regression results indicate that installment bonuses are about 71.0 percent as effective as lump-sum bonuses, and from this we have inferred a real discount rate of 18.5 percent. The situation is altered when we allow for progressive income taxation.[2] The individual may still prefer a lump-sum bonus since deferred income must be discounted. However, progressive income taxation implies that the individual's total tax payments are higher when all of his income is earned in a single year. Hence the individual's preference for a lump-sum bonus, and the corresponding relative effectiveness of lump-sum bonuses in inducing reenlistments, may be mitigated or even reversed. Moreover, our estimates of the discount rate may be biased.

To explore this matter analytically, let $t[I]$ denote taxes as a function of income, where $0 < t'[I] < 1$ and $t''[I] > 0$, so that taxation is progressive. Let B denote the annual bonus installment, so that the lump-sum bonus is equal to 4B. It is easily shown that the installment bonus

[1] This estimate assumes that reenlistees on the margin perfectly anticipated future inflation. If in fact they underestimated (overestimated) the actual inflation rate, then the real discount rate is higher (lower) than our estimate.

[2] We ignore the possibility of income averaging until the next section.

increases the discounted present value of the individual's after-tax income stream by

$$(4) \qquad \sum_{i=1}^{4} \frac{B\,(1 - t'[I_i + B])}{(1+r)^{i-1}}$$

where I_i is taxable income excluding the bonus. By contrast, the lump-sum bonus increases the individual's present value by

$$(5) \qquad 4B\,(1-t'[I_1 + 4B])$$

The individual will prefer the lump-sum bonus if r is very large or if t" is very small (i.e., taxation is not very progressive), or if income in the absense of a bonus grows at a high rate. However, the individual will prefer the installment bonus if r is very small or if t" is very large or if income in the absense of a bonus grows slowly.

The relative effectiveness of installment bonuses is no longer given by equation (3), but is now equal to the ratio of equations (4) and (5) or,

$$(6) \qquad .25 \sum_{i=1}^{4} \frac{1 - t'[I_i + B]}{1 - t'[I_1 + 4B]} \left(\frac{1}{(1+r)^{i-1}} \right)$$

Equation (6) reduces to equation (3) for proportional taxation (t" = 0), but exceeds equation (3) for t" > 0 and may even exceed unity. Moreover, the discount rate implied by setting equation (6) equal to the empirical ratio of 71.0 percent will exceed the discount rate computed earlier using equation (3). Hence our earlier estimate of 18.5 percent represents a lower bound to the real discount rate. The implied discount rate is larger when we consider progressive income taxation because discounting now must be sufficiently important not only to yield the empirical effectiveness of lump-sum bonuses, but to do so in spite of the tax disadvantage of lump-sum bonuses.

V. THE EFFECT OF INCOME AVERAGING

In the previous section, we demonstrated that our estimate of 18.5 percent as the real discount rate represents a lower bound under progressive taxation. In this section, we consider the further effects of income averaging. We will see that our estimate of 18.5 percent in fact represents an upper bound when income averaging is allowed.

The individual receiving a lump-sum bonus may choose to income average in order to reduce his total tax payments. Let I_0 denote the sum of taxable income during the four "base years" prior to the year in which the bonus is received. Let I_1 again denote taxable income excluding the bonus during the year in which the bonus is received. Then the tax liability under income averaging, t_a, according to Form 1040 Schedule G for 1980 is equal to

$$(7)\quad t_a = t[.24I_0 + .20(I_1+4B)] + 4(t[.24I_0 + .20(I_1+4B)] - t[.30I_0]).$$

Without the bonus, the individual would have earned $I_1 - t[I_1]$ after tax. With the bonus, he earns $I_1 + 4B - t_a$. Hence the net value of the bonus equals:

$$(8) \qquad 4B - (t_a - t[I_1])$$

In this expression, the term 4B measures the lump-sum bonus payment, while the term $t_a - t[I_1]$ measures the additional tax payments attributable to the bonus.

The relative effectiveness of installment bonuses is now given by the ratio of equations (4) and (8) as

$$(9) \qquad \frac{B}{4B - (t_a - t[I_1])} \sum_{i=1}^{4} \frac{1 - t'[I_i + B]}{(1+r)^{i-1}} .$$

The form of equations (7) and (9) make it difficult to solve analytically for the implied discount rate that sets equation (9) equal to the empirical ratio of 71.0 percent. Therefore, we have numerically analyzed equations (7) and (9) to solve for the discount rate under a reasonable set of assumptions.

Consider a married individual in the Navy who files jointly with his spouse, who claims himself and his spouse as exemptions, and who has no income outside of military pay. We assume this individual sailor faces the FY80 mean bonus multiple of 1.57 if he reenlists in 1980. Table 3 lists the income stream (excluding any bonus) that such an individual could have expected had he entered the Navy at the start of 1976 and reenlisted during his fifth year in 1980.[1]

Year	Military Pay
76	$4,830
77	5,200
78	5,940
79	6,770
80	7,920

Table 3 - Income Stream of Typical Individual

Without the bonus, our individual would earn $7,920 in 1980 and pay federal income tax of $362.[2] The lump-sum bonus at a multiple of 1.57 equals $4,145. Without income averaging, he would pay income tax of $1,076 on his total income of $12,065. With income averaging, he would pay only $972, a saving of $104.

Evaluating equation (8), the net value of the bonus equals the bonus payment minus the additional tax payments of $972 - $362 = $610. Hence the net value equals $4,145 - $610 = $3,535.

To evaluate the remaining elements in equation (9), we must estimate I_i and hence $t'[I_i + B]$ for i=1,2,3,4. We have already calculated $I_1 = 7920$. Since B = 1036, we may compute from the 1980 tax table $t'[I_1 + B] = 0.16$.

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[1]We assume a median promotion path. Hence the individual is promoted to rank E-2 early in his first year, E-3 at the beginning of his second year, E-4 halfway into his third year, and E-5 halfway into his fifth year.

[2]We ignore state and local income taxation. There are several states that do not tax the military income of servicemen. Residency is simple to change, and this information is well known by service members.

We estimated I_i over the remaining three years of the reenlistment term. For this purpose, we tracked the individual through the rows of the FY81 military pay table corresponding to the sixth, seventh, and eight years of service. Our estimates of I_i and $t'[I_i + B]$ from the tax tables are noted in Table 4.

Year	Military Pay	Marginal Tax Rate
81	$ 8,970	0.16
82	9,560	0.16
83	10,540	0.18

Table 4 - Income Stream and Marginal Tax Rates.

Given these assumptions, equation (9) implies a nominal discount rate of 27.4 percent and hence a real discount rate of 16.8 percent. This estimate is very close to the estimate 18.5 percent that ignored progressive taxation. It appears that tax considerations make little difference in the calculations as long as income averaging is allowed.

VI. POLICY IMPLICATIONS

We have estimated a real personal discount rate of approximately 17 percent. It is unlikely that the government uses a real discount rate as high as this and, in fact, most previous estimates have been in the area of 10 percent[1]. Therefore, in the simple case, the net present cost to the government is higher than the net present value to the bonus recipient and installment bonuses are inefficient relative to lump-sum bonuses.

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[1] See Baumol (1968), Feldstein (1964), and Marglin (1963) for a detailed discussion of this issue.

The situation becomes considerably more complex, however, with the introduction of contract enforcement costs. A combination of lump-sum and deferred payments may now be most efficient, depending not only on the relative size of government and personal discount rates but also on the relationship of enforcement costs to various bonus payment schemes. Also, up front payment in a lump-sum may have an adverse impact on incentives for performance.

To illustrate the magnitudes of the factors involved, we compare a lump-sum policy to the current policy whereby 50% of the bonus is awarded up front and the remaining 50% paid in equal annual installments. A lump-sum bonus of B_1 will have cost to the government of B_1 plus the present value of the expected default costs denoted R. We define R as the discounted expected value of the unamortized portion of the bonus payment when the individual defaults prior to the end of the contracted reenlistment period.[1]

To keep the quantity and quality of reenlistments constant, the sum, B_2 of the installment payments must have a discounted present value equal to B_1 when evaluated at the sailor's discount rate of r_s. This implies the relationship

$$(10) \qquad B_1 = .5B_2 + \sum_{i=1}^{4} \frac{.125B_2}{(1 + r_s)^i}$$

$$= .5B_2 + \frac{.125B_2}{r_s} \left(1 - \frac{1}{(1 + r_s)^4}\right).$$

[1]We have deliberately biased this analysis against the lump-sum bonus by assuming a zero default rate in the case of the partial installment bonus.

The cost of the installment bonus must be evaluated at the government discount rate of r_g, and presumably $r_g < r_s$. We may express this cost as

$$(11) \qquad .5B_2 + \frac{.125B_2}{r_g}\left(1 - \frac{1}{(1 + r_g)^4}\right).$$

Substituting (10) into (11), the cost of the installment bonus equals

$$(12) \qquad \frac{B_1\left[.5 + \frac{.125}{r_g}\left(1 - \frac{1}{(1 + r_g)^4}\right)\right]}{\left[.5 + \frac{.125}{r_s}\left(1 - \frac{1}{(1 + r_s)^4}\right)\right]}.$$

Recall that we have chosen B_2 to keep the number of reenlistments constant between the two payment schemes. Hence, the combination of lump-sum and installment bonuses will be socially efficient if and only if the cost to the government in equation (12) is lower than the cost of the lump-sum bonus, $B_1 + R$. Therefore, the partial installment bonus will be socially efficient if and only if

$$(13) \qquad \frac{.5 + \frac{.125}{r_g}\left(1 - \frac{1}{(1 + r_g)^4}\right)}{.5 + \frac{.125}{r_s}\left(1 - \frac{1}{(1 + r_s)^4}\right)} < 1 + \frac{R}{B_1}$$

The left side of this expression equals 1.063 when evaluated at r_s = 17 percent and r_g = 10 percent; therefore the ratio R/B_1 must be at least 0.063 to justify the partial installment bonus plan. In other words, the cost of default must exceed 6.3% of total bonus program costs. Since we have implicitly assumed a zero default rate for the partial installment bonus, this value represents a lower bound to the true value required to justify installment bonuses.

Actual data are available to analyze the optimality of the installment bonus program. The total amount of new bonus payments in FY79 was $174.2 million. A combination of actual data (FY79 and FY80) and Defense Audit Service projections estimate that the <u>undiscounted</u> (and therefore overestimated) default costs will be approximately $4.0 million, or only 2.3% of lump-sum bonus cost. This is barely one-third the default costs required to justify installment bonus program enacted by Congress.

VII. CONCLUSIONS

We have compared the differential effects of lump-sum and installment bonuses paid to Navy enlisted personnel. From this comparison we estimate that, on the margin, individuals have a real discount rate of about 17 percent. This estimate takes account of both inflation and progressive income taxation. We also find that tax considerations make little difference in the calculations as long as individuals income average when they receive lump-sum bonus payments.

In the simple case, as long as the government has a real discount rate of less than 17 percent, it is more efficient to pay lump-sum rather than installment bonuses to increase the supply of military reenlistments. Returning to a system of installment bonuses would reduce the number of reenlistments for a given level of the bonus program budget or, equivalently, increase the budget required to achieve a given number of reenlistments.

When the costs of contract default are considered, however, this preference for "up-front" payments may not be optimal. The current bonus policy attempts to take this into account somewhat arbitrarily by providing an equal mix of current and deferred payments. Using our estimate of the personal discount rate and a commonly used estimate of the social discount rate we showed the minimum contract enforcement costs necessary to justify this policy on efficiency grounds. Recent evidence on contract nonfulfillment shows that this policy places far more emphasis on deferred payments than is warranted on efficiency grounds. A return to lump-sum bonuses would achieve the same number of reenlistments at a lower cost to taxpayers.

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